CHAPTER 1: INTRODUCTION

It is widely recognized that the greatest hazards to life loss, injury, property damage and other economic losses from earthquakes are posed by existing buildings that were not designed and constructed to resist strong ground motions. Therefore, one of the objectives of the Earthquake Hazards Reduction Act of 1977 (P.L. 95-124) was "...the development of methods for...rehabilitation, and utilization of manmade works so as to effectively resist the hazards imposed by earthquakes..." The National Earthquake Hazards Reduction Program submitted to the Congress by the President on June 22, 1978, stressed that "...it is important that hazards be reduced from those (substandard) structures presenting the greatest risks in terms of occupancy and potential secondary impact."

FEMA's Program for Reducing Seismic Hazards in Existing Buildings

Since 1984, the Federal Emergency Management Agency (FEMA) has had underway a comprehensive, closely coordinated program to develop a body of engineering practices to increase the ability of existing buildings to withstand the forces of earthquakes. Societal implications and economic issues related to the use of these improved practices have also been examined. The first project was the formulation of a comprehensive 5-year plan on what needed to be done and what the required resources would be. This plan was completed in 1985 and published under the title An Action Plan for Reducing Earthquake Hazards of Existing Buildings (FEMA 90). This plan identified priority actions to be taken by the public and private sectors. FEMA has used this plan as the basis for developing a multi-volume, continuing series on the seismic rehabilitation of existing buildings.

At a cost of about $15 million, two dozen publications and a number of software programs and audio-visual training materials have already been produced and distributed for the use of design professionals, buildings regulatory personnel, educators, researchers, and the general public. The program has proceeded along separate, but parallel approaches in dealing with private-sector buildings and Federal buildings.

Private-Sector Buildings

The "technical platform" of consensus criteria on how to deal with some of the major engineering aspects of seismic rehabilitation of buildings is already available to private-sector practitioners and other interested parties. This technical material is contained in a trilogy, with supporting documentation, completed in 1989: 1) a method for rapid visual screening of buildings that might be hazardous in future earthquakes that can be conducted without gaining access to the buildings themselves; 2) a methodology for a more detailed evaluation of a building that identifies structural flaws that have caused collapse in past earthquakes and might do so again in future earthquakes; and 3) a compendium of the most commonly used techniques of seismic rehabilitation.

In addition to these engineering topics, the program has also been concerned with the societal and economic implications of seismic rehabilitation. The costs of seismically rehabilitating buildings were first reviewed in 1988 and have just recently been updated, expanded in scope, and improved in accuracy. Two benefit-cost models and associated software for application to both private-sector buildings and Federal buildings have also been developed. Further, for the use of decision makers at the local level, a series of volumes present an array of socio-economic issues that are likely to arise in a locality that undertakes seismic rehabilitation of its building stock; ways to identify problems and methods to analyze them; and means to stimulate interest in seismic rehabilitation of buildings in appropriate localities.

The culminating program activity for private-sector buildings will be the completion in the fall of 1997 of a comprehensive set of nationally applicable guidelines with commentary, on how to rehabilitate buildings so that they will better withstand earthquakes. This is a multi-year, multi-million dollar effort that represents a first of its kind in the United States. The guidelines will allow practitioners to choose design approaches consistent with different levels of seismic safety as required by geographic location, performance objective, type of building, occupancy, or other relevant considerations. Before being issued, the two documents will be given consensus review by representatives of a broad spectrum of users, including the construction industry, building regulatory organizations, building owners and occupants' groups academic and research institutions, financial establishments, local, State and Federal levels of government, and the general public. This process is intended to insure their national applicability and encourage their widespread acceptance and use by practitioners once the documents are completed. It is expected that, with time, this set of guidelines will be adopted by model building code organizations and standards-setting groups, and thus will diffuse widely into the building practices of the United States.

Significant corollary products of this activity are also expected. Principal among them will be improved seismic rehabilitation cost data; an engineering applications handbook; a plan for a structured transfer of the technology embodied in the guidelines; and an identification of the most urgent research and development needs.

Federal Buildings

A set of technical criteria intended to provide Federal agencies with minimum standards for both the seismic evaluation and the seismic rehabilitation of buildings in their inventories is in advanced stages of preparation. The performance level established in these standards is life-safety for building occupants and the general public. To facilitate the application of the standards by users, a commentary has also been prepared. In addition, an Executive Order to promulgate the standards has been drafted. These materials were given consensus approval by the Interagency Committee on Seismic Safety in Construction (ICSSC) which represents 30 Federal Departments and Agencies, and are expected to be ready for submission to the Executive Office of the President for consideration by the summer of 1994.

Publications

By the end of 1993, the following publications in this series had been published:

- A handbook (and supporting documentation) on how to conduct a rapid, visual screening of potentially hazardous buildings - Rapid Visual Screening of Buildings for Potential Seismic Hazards (FEMA 154 and 155).
- The first collection (and supporting documentation) of typical costs for the seismic rehabilitation of buildings - Typical Costs for Seismic Rehabilitation of Existing Buildings (FEMA 156 and 157).
- An engineering report which identifies the generally accepted techniques for the seismic rehabilitation of hazardous buildings - Techniques for Seismically Rehabilitating Existing Buildings (FEMA 172).
- A handbook (and supplemental readings) on establishing priorities for the seismic rehabilitation of buildings - Establishing Programs and Priorities for the Seismic Rehabilitation of Buildings (FEMA 173 and 174).
- A handbook (and supporting documentation) on a methodology for evaluating the seismic safety of existing buildings - Handbook for Seismic Evaluation of Structures (FEMA 175 and 178).
- An evaluation of existing and potential financial incentives in the private and public sectors that would encourage a locality to undertake a seismic rehabilitation program - Financial Incentives for Seismic Rehabilitation of Hazardous Buildings - An Agenda for Action (FEMA 198 and 199).
- A methodology (and accompanying software) for conducting benefit-cost analysis of private sector buildings - A Benefit-Cost Model for the Seismic Rehabilitation of Buildings (FEMA 227 and 228).

- An examination of most significant technical and societal issues likely to confront the writers of the planned set of guidelines on the seismic rehabilitation of buildings with suggested solutions - Seismic Rehabilitation of Buildings - Phase I: Issues Identification and Resolution (FEMA 237).

The Role of Benefit-Cost Analysis in the Seismic Rehabilitation of Existing Buildings

What Is Benefit-Cost Analysis?

Benefit-cost analysis provides estimates of the "benefits" and "costs" of a proposed seismic rehabilitation project. This methodology estimates the seismic performance of a building before and after the proposed rehabilitation project, including expected damages to the building and contents, casualties, and extent of loss of functionality of the building. Estimated future expected benefits are reduced to their net present value and summed. When benefits are greater than costs the benefit-cost ratio is greater than one and the proposed project is economically sound.

Is it Worth it?

This is the primary question about seismic rehabilitation projects which are designed to reduce expected damages and casualties from future earthquakes. Decision making about the prospective seismic rehabilitation of existing Federal buildings may be difficult because of the myriad of complex and often contentious engineering and public policy issues involved.

Benefit-cost analysis is a powerful tool which can help determine whether the future benefits of a prospective seismic rehabilitation are sufficient to justify the present costs of the project. The benefit-cost methodology in this report (and accompanying software) provides estimates of the benefits (i.e., avoided future damages and losses) of the seismic rehabilitation of Federal government buildings. The model is also applicable to state and local government buildings.

The Benefit-Cost Model

Benefit-cost analysis provides estimates of the "benefits" and "costs" of a proposed seismic rehabilitation project. The benefits considered are avoided future damages and losses which are expected to accrue as a result of the rehabilitation project. Costs considered are those necessary to implement the specific rehabilitation project under evaluation. Costs are generally well determined for specific projects for which engineering design studies have been completed. Benefits, however, must be estimated probabilistically because they depend on the improved performance of the building in future earthquakes, the timing and severity of which must be estimated probabilistically. In the present model, the benefits included are: avoided damages to the building and contents, avoided rental income losses, avoided relocation costs, avoided loss of government services, and avoided casualties.

The "benefits" calculated by the methodology are expected future benefits which are calculated over a "planning horizon" (i.e., the useful lifetime of the rehabilitation project). To account for the time value of money, a net present value calculation must be performed. This calculation is done automatically in the program, using the discount rate and project useful lifetime entered by the user.

Results of benefit-cost calculations are presented two ways: first, the benefit-cost ratio (benefits divided by costs) and second, the present value criterion (benefits minus costs). A benefit-cost ratio above one, or, equivalently, a positive present value indicates that benefits exceed costs and that the rehabilitation is economically justified, <u>under the assumptions made in the calculation</u>. The validity of a benefit-cost calculation and the robustness of conclusions drawn therefrom depend entirely on the validity of the data used in the calculations. Calculations based on detailed, building-specific engineering analysis will be much more accurate (and correspondingly more useful), than calculations based largely on typical or default values of input parameters. Therefore, decisions should not be made solely on the basis of benefit-cost results. Rather, prudent decision making must include assessment of the reliability of the benefit-cost results.

What Data Are Needed to Run the Model?

For any benefit-cost analysis, basic information about the building under consideration is required, including: building type (structural system) of the building (e.g., unreinforced masonry), floor area, replacement value, occupancy, use and function and others. Most importantly, estimates of the buildings seismic performance both in its existing condition and post-rehabilitation must be made. Default or reference values are provided for most of the input parameters (based on the building type). However, more reliable analyses are obtained when additional building-specific information, including expected seismic performance, is available.

Probabilistic Seismic Risk Assessment

Seismic risk assessment for benefit-cost analysis must be probabilistic because the timing and severity of future earthquakes is unknown. The benefit-cost program uses the expected annual probability of earthquakes in each "bin" or level of seismic ground motions (expressed as Modified Mercalli Intensity, MMI, and effective peak ground acceleration, PGA) to perform an expected value calculation. For example, if at a site under consideration, the annual probability of earthquakes of MMI VIII is 1%, then there is a one percent chance per year of such an earthquake. If each such earthquake causes $1,000,000 in damages, then on average (over a long time period) there will be $10,000 per year in damages. The $10,000 per year in average damages is the "expected" or statistical average damages per year. If these damages are avoided by a rehabilitation project, then the expected or statistical average damages avoided (i.e., the benefits) are $10,000 per year. To count fully the benefits of a seismic rehabilitation, the expected benefits of avoiding damages from the full range of damaging earthquakes must be counted, rather than simply considering one scenario or design earthquake.

What Are the Intended Applications?

There are two primary intended applications for this methodology: first, to roughly screen or prioritize a large list of buildings and second, to evaluate in detail one or more specific alternatives on a single building for which detailed engineering analysis exists. To screen a large list of buildings, a rough analysis could be made using typical or default data, although incorporation of more detailed building specific information would improve the validity of the results. To evaluate one or more specific rehabilitation options for a single building, detailed engineering analyses of the alternatives are essential.

Who Are the Intended Users?

The benefit-cost methodology presented in this report (and accompanying software) is intended for use by facility managers, design professionals (engineers and architects), and others involved in decision making about the seismic rehabilitation of Federal buildings. A technical background is not a prerequisite for using the methodology. However, a working knowledge about the general principles and terminologies relevant to the seismic performance of buildings, and some basic personal computer skills are necessary.

What the Benefit-Cost Model Can Do

The benefit-cost model performs the necessary calculations to determine how the expected future benefits of a specific seismic rehabilitation project compare to the costs. The model also generates scenario damage estimates of expected damages, other economic losses, and casualties per earthquake event (as a function of Modified Mercalli Intensity, MMI, and effective peak ground acceleration, PGA). These scenario damage, loss, and casualty estimates may prove useful to decision makers.

What the Benefit-Cost Model Cannot Do

The benefit-cost model cannot make a decision about whether or not to undertake the seismic rehabilitation of a building because decisions about rehabilitations usually depend on a great many factors and policy decisions well outside the confines of benefit-cost analysis. For example, basic policy decisions about what level of life safety and what level of post-earthquake performance are desired cannot be decided by a benefit-cost program. Similarly, seismic rehabilitations are frequently done in combination with other building renovation, such as interior refurbishing, upgrading electrical, mechanical, and plumbing systems, or hazardous material (e.g., asbestos) abatements. The seismic benefit-cost model cannot evaluate such projects as a whole because the model only considers seismic benefits and costs. In addition, decisions about whether or not to rehabilitate a building frequently depend on other factors such as budgets available, priorities for seismic safety vs. other program needs. As with new construction, decisions about rehabilitation of existing buildings may also be made partially on factors such as building location, desirability, availability of alternative space, and so on. Therefore, while the model can determine how the benefits of specific rehabilitation alternatives compare to the costs, it does not provide an absolute answer as to whether or not to undertake the seismic rehabilitation of a building.

CHAPTER 2: GETTING STARTED

This chapter describes the computer hardware and software required to run the program and how to install the benefit-cost program on your computer. Chapter 3 (Program Basics) describes the basics of using Quattro Pro for Windows (QPW), how to get around in the program, and how to enter the data requested. Chapter 4 (Tutorial - Worked Example) provides a fully worked example with guidance for the novice user.

QPW works very much like other spreadsheet programs such as Lotus 1-2-3, or Excel, so that experience with any of them is almost 100% transferrable to QPW. However, even if you have little or no experience with spreadsheet programs, the benefit-cost program is self-contained and easy to use.

HARDWARE AND SOFTWARE REQUIRED

Computer Hardware

This program requires an IBM-compatible computer (PC). The CPU must be a 386 or higher; the program will run faster with a 486 or Pentium CPU. In addition, the computer must have:

1. At least 4 megabytes of memory (RAM).
2. A hard drive with at least 15 megabytes of free disk space.
3. A high density (HD) 3.5" floppy disk drive.

The benefit-cost program files require a large amount of disk space, about 2 megabytes per file saved. Therefore, it is desirable to have a large hard disk if you anticipate saving a substantial number of files. Alternatively, files can be saved on high density (HD) floppy disks. However, because of the file size, the files must be compressed using utilities available on recent versions of DOS or as separate utility programs (such as PKZIP).

Computer Software

This program is a Windows program; therefore, your computer must have Windows (Version 3.1 or higher) installed.

Windows

To install Windows:

1. Turn on your computer.
2. Insert the **Windows Disk 1** in the drive you want to use for the installation and close the drive door.
   Windows Setup lets you use any active disk drive.
3. To make the installation drive active, type the drive letter followed by a colon (A: or B:) and press **Enter**.
4. Type **setup** and press **Enter**.
5. Follow the instructions on the screen.

   The Setup program's instructions should be self-explanatory. But, if you do have questions about any of the procedures or options, you can request on-line Help by pressing the F1 key. For more information, see **Microsoft Windows User's Guide**.

   HINT: The installation routine will ask if you want to choose a "custom" installation or allow Windows to perform a "standard" installation. Most computers will operate well if you allow Windows to self-install, i.e., select the "standard" installation, not the "custom" installation.

The benefit-cost program runs as templates in QUATTRO PRO FOR WINDOWS (QPW). You must have QPW (Version 5.0) installed on your computer.

Quattro Pro for Windows

To install QPW:

1. Be sure you are in WINDOWS (i.e., install WINDOWS first): open WINDOWS if it does not automatically come up when you turn on your computer. To open WINDOWS, at the DOS prompt, **C:>** type **WIN**
2. Insert the **QPW Disk 1** in the drive you want to use for the installation and close the drive door.
3. With your mouse, point the cursor on **File** on the menu bar (at the top of your screen), press and hold the left button of your mouse. This will highlight the selected item. While holding down the left mouse button, move the mouse until **Run** is highlighted.
4. On the **Command Line**, i.e., inside the box which will appear next on your screen, type

   a:install.exe

   or **b:install.exe**

   depending on which drive the QPW disk is in. Be sure to type the command exactly as written: **do not** add spaces or change punctuation. Then left-click the mouse on **OK**.
5. Enter the requested information in the Installation dialog box which will appear on your screen. Accept the default choice of QPW for the Quattro Pro directory.
6. Quattro Pro will ask you for various information during the installation. Simply type the response and press **Enter** or click the mouse on **OK**. The default setting are usually suitable for your first installation of Quattro Pro.
7. After entering the information requested in the Installation Dialog Box (e.g., your name), click on **Install** to continue.
8. Follow instructions (e.g., change from Disk 1 to Disk 2) as they appear.
9. Your QPW installation is complete!

INSTALLING THE PROGRAM

Network Systems

Computer networks may be set up and managed in many different ways. Therefore, this manual cannot give detailed instructions for installing the program on a specific network system. To install the benefit-cost program on computer which is connected to a network system, give the program disk and the User Guide to your computer system operator. After installation is completed, go to the Start QPW section on page 1 of Chapter 3.

Stand-Alone Computers

1. Turn on your computer.

2. If you are not at a DOS prompt (such as **C:\>**) either exit from WINDOWS to DOS, or select a DOS prompt from within WINDOWS. To exit from WINDOWS, highlight **File** on the menu, hold down the mouse button and highlight **Exit**. The program will display: "This will end your Windows Session." Click on **OK**. Your screen should show: **C:\>**

If your hard disk drive is designated **D**, or some other letter, that letter will appear in place of **C**;

3. Insert the Benefit-Cost Program diskette (3.5") in either the A or B drive of your computer (whichever floppy drive is the high density 3.5" drive);

4. At a DOS prompt (**C:\>**),
If the Program diskette is in the **a** drive, type: **a:install**
If the Program diskette is in the **b** drive, type: **b:install**

5. The install program will automatically create a new subdirectory on your C drive: **C:\FB**

6. Two files will be loaded into the **C:\FB** directory:

A. An example file with all data entries filled in:
BC_EXAMP.WB1

B. A blank file, for user data input:
BC_BLANK.WB1

7. **PROGRAM INSTALLATION IS COMPLETE!**

CHAPTER 3: PROGRAM BASICS

This chapter provides basic information about starting and running Quattro Pro and the benefit-cost program, along with helpful hints.

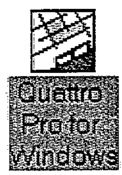
STARTING QUATTRO PRO (QPW)

Start Windows

Quattro Pro is a WINDOWS program; therefore you must first start WINDOWS before starting Quattro Pro. If you are not already in Windows, type WIN at a DOS prompt to start Windows.

Start QPW

After starting WINDOWS, click the left mouse button on the symbol (the "icon") or the group window labeled Quattro Pro for Windows (QPW). Then, double-click the left mouse button on the QPW icon within the window.



> In this tutorial, when you read "click on" it is a short way to say "click on the left mouse button."

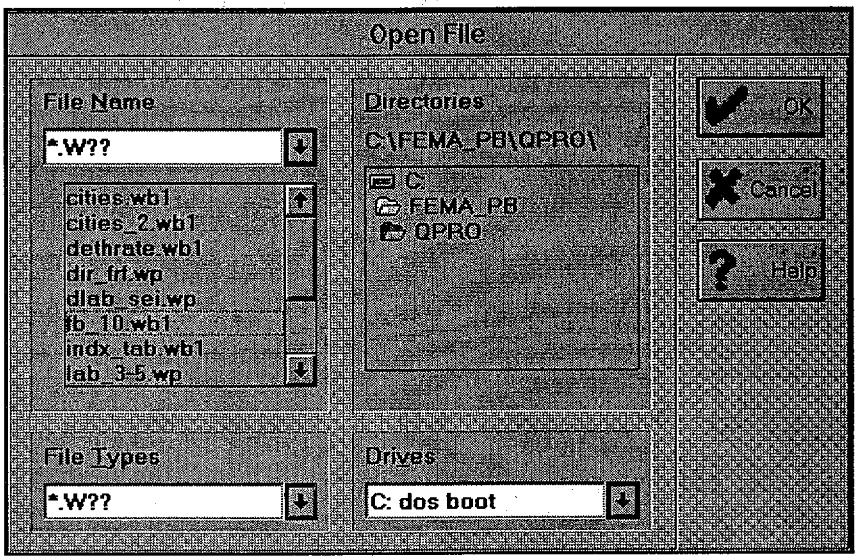
Quattro Pro for Windows works very much like any other Windows spreadsheet or any other Windows program, including word processors. Quattro Pro commands are initiated by clicking on pull-down menus at the top of the screen or by clicking on the speed buttons below the menu lines.

To use the Benefit-Cost Program, you need to know only a little about Quattro Pro. Once the Benefit-Cost Program is loaded, the data entry, calculations, and printing of results can be accomplished entirely within the program, with minimal use of Quattro Pro commands.

Opening Files

The menu bar along the upper edge of the QPW window will display a **File** command at the left side. Click on the **File** command. When the menu opens, click on the **Open...** line.

The screen will display two boxes side by side: **File Name** and **Directories.**



Click on the **C:** in the **Directories** box on the right side of the screen. Use the mouse to move the cursor to the **FB** directory where the benefit-cost model is located, and double click.

Double click on the **BC_EXAMP.WB1** line to load a completed example, or on **BC_BLANK.WB1** to load a blank spreadsheet. Or, click once on the file you wish to open, then click on **OK**.

The computer will load the benefit-cost model. Loading will take only a few seconds on a fast computer, but may take up to several minutes on a slow computer. The bottom right corner of the screen (Status line) will display **WAIT** while the model is loading and **READY** when the model is loaded.

As you continue to use the Benefit-Cost Program and save files, the **File Name** box will contain the names of all of your files which have the **.WB1** ending. Double-clicking on the desired file will open any of these files. Please see **NAMING AND SAVING FILES** on page 3-7.

Screen Display

When the Benefit-Cost Analysis program is loaded, the first screen visible is the **Sign-On Screen.**

Benefit-Cost Analysis of the

Seismic Rehabilitation of Federal Buildings

Version 1.0
June 15, 1994

Building Name:	Court House
Address:	123 I St
City, State, Zip:	Ekalaka, MT 21345
Analyst:	GLH
Rehabilitation Project:	Install shear walls
Run Identification:	123456

If the words extend past the right-hand side of your computer screen or if the image is too small, change the **Zoom List** by following these steps:

1. Click on the **Zoom List** arrow, located in the first row of symbols (the "SpeedBar") at the top of the screen;

2. While holding down the left-hand mouse button, move the mouse until the correct value (e.g., 80) is highlighted. It may take a little trial-and-error to determine the best value for your screen.

Moving Around in the Program

There are several easy ways to move around the Benefit-Cost Program:

1. Use the mouse to place the cursor wherever you want to be on a page and click on that location.
2. To move **left-right** on a page, use the cursor arrows on the keyboard, or the horizontal scroll bar at the bottom right of the screen.
3. To move **up-down** on a page, use the cursor arrows on the keyboard, or the vertical scroll bar at the right hand edge of the screen.
4. To move to the top of any page in the program, press the **Home** button on the keyboard.
5. To move to a specific location within the program, use the custom **Menu Tree** (described next) which appears at the top of the screen. Click on the desired menu item; the submenu (a list of available choices) appears. Click on the desired submenu item.

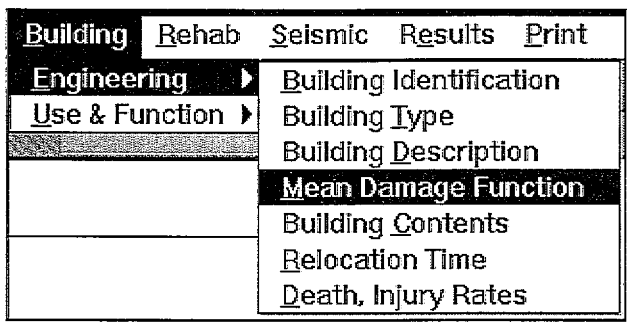
Benefit-Cost Menu Tree

The benefit-cost model is driven from a customized menu tree. The menu appears at the top of the display screen (after the model is loaded):

The underscored letter of the name indicates that this menu item can be accessed by clicking on the menu **or** by the **/X** keyboard command, where "**X**" indicates the underscored letter in the menu name. For example, **Rehab** can be accessed by typing **/R**.

In addition to the main menu, there are submenus which appear when the main menu heading is clicked on. Submenus are accessed in the same manner as the main menu heading.

For example, to move to the **Mean Damage Function** screen, click on **Building**. The **Engineering** submenu appears, and displays seven choices, including the **Mean Damage Function**. Move the cursor down until **Mean Damage Function** is highlighted.



The complete Benefit-Cost Menu Tree is given on the following page.

Menu Tree

CUSTOMIZED BENEFIT-COST MENU TREE

- File
  - Save
  - Save As...
  - Quit
- Model
  - Version
- Building
  - Engineering
    - Building Identification
    - Building Type
    - Building Description
    - Mean Damage Function
    - Building Contents
    - Relocation Time
    - Death, Injury Rates
  - Use & Function
    - Occupancy Data
    - Value of Lost Gov't Services
    - Functional Downtime
    - Rental Income
- Rehab
  - Project Description
  - Costs
  - Effectiveness of the Rehab
  - Death, Injury Rates
- Seismic
- Results
  - Damages
  - Benefit Cost Results
  - Injuries & Deaths
  - Summary
- Print
  - Model Version
  - Building Engineering
    - Facility Class
    - Mean Damage Function
  - Building Use & Function
    - Occupants
    - Rental Income
  - Rehab
  - Seismic Information

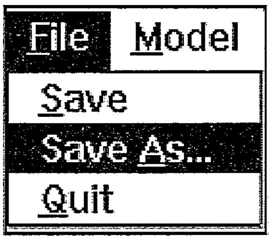
Results
- **Damages**
- **Benefit-Cost Results**
- **Death & Injuries**
- **Summary**

All Data Tables
All Tables

Naming and Saving Files

Each benefit-cost analysis file must be saved with a new name to avoid overwriting previous files. **Each file that you want to save MUST have a unique name.**

New names can be entered, as a file is saved, by using the **Save As** command. To enter a new name for an open file, click on **File** (in the menu on the second line of the screen), then click on **Save As**, and enter a new name in the file name box. Names can have up to eight letters or numbers, then a period, followed by three letters or numbers: e.g., **TUTORIAL.WB1**

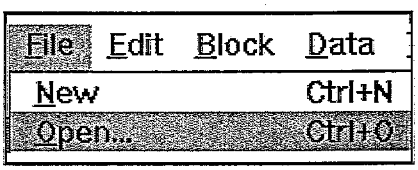


HELPFUL HINT:

Save benefit-cost program files with an extension of **.WB1**

For example: if you want to save a file as **Run17**, save the file as **Run17.WB1**.

When you use the **File|Open** command, Quattro Pro automatically lists all files in which the extension (the three letters after the period) begin with **.W** and thus your program files will be easy to find.



Oops!

If you accidentally overwrite one of the original program files by saving a file with user-entered data without changing the name, the original program file will be lost (overwritten by the new file).

To recreate the original program file, check to see if a backup copy exists: it will have the same name, followed by a **.bak** extension (ending), e.g., **sample.bak** or **example.bak**. Copy this file to the original.

1. Click on the **File** menu at the top of the screen.

2. Next, **Open** the **.bak** file (see page 6 for instructions on opening a file).

3. Select **Save As** and save the file with a new name, as described on page 3-7, **Naming and Saving Files.**

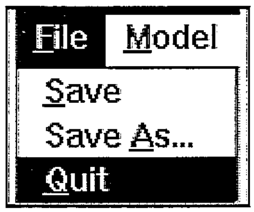
Helpful Hint: If all else fails, reinstall the file from the original floppy disk as described in Chapter 2, **Installing the Program**.

To Start A New Analysis

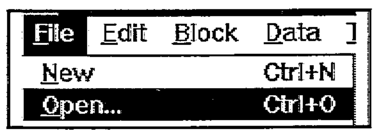
If you want to do another analysis:

1. First, save the existing open file with a new name (see **NAMING AND SAVING FILES**, page 3-7).

2. Quit the Quattro Pro file which you have been using: with the cursor highlight **File** and **Quit**, since the file is already saved under a new name.



3. Next, click on **File**, then click on **Open** to start a new analysis (see **Opening Files**, page 3-2).



To Exit From the Program

First, save your work with a new name, by using the **File]Save As** command described above.

Click on **File**, then click on **OK** to leave Quattro Pro.

Cell Colors

Before you begin the data entry process, note that all areas (cells) of the program screens are color coded to remind the user what type of information each cell contains.

The cell type appears in the Style List window when the cursor is clicked on a cell. The Style List window is in the upper SpeedBar.

There are six cell colors which indicate different types of entries:

Cells are color coded to inform the user what the cell contains. The cell format name appears in the center Style List window of the first speedbar when the cell is activated by the cursor.

Green cells require the user to enter data concerning the building or project. Green cell data entries directly affect the calculated results. Style List Title: Data Input

Pink cells contain information about the building or project. Pink cell entries do not affect the calculated results. Style List Title: Information.

Purple cells contain information that was entered by the user in other screens. Style List Title: Carry Over.

Orange cells contain default data. The values cannot be changed. Style List Title: Default.

Blue cells can be used to override default data with project specific data. Style List Title: Override Default.

Yellow cells contain calculated results from the model. Style List Title: Results.

Data Entry

To enter data into a cell (block) in the program, first move the cursor to the cell where you want to enter the data. Then, type the desired information. As you type, the characters appear in the input line below the menus and speed buttons.

Only when you press ***Enter*** or an arrow key or click the check mark button (✓) does Quattro Pro move the characters into the program cell.

> Helpful Hint: User data entries can be made only in the GREEN, BLUE, or PINK data entry cells (blocks).

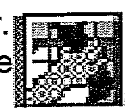
If you attempt to enter data in cells which are not GREEN, BLUE, or PINK, you will see a "protected cell" error message. Other cells are "protected" to prevent inadvertent changes to the program. As with other error messages, click on **OK** or press the **Esc** key to return to data entry.

Correcting Errors

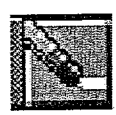
If you make a mistake while typing, press ***Backspace*** to erase. To clear the entire entry, click the **X** box to the <u>left</u> of the input line or press the ***Esc*** button on the keyboard.

After pressing ***Enter***, if you find you made a typing mistake or want to change an entry, type the entry over again or click inside the text on the input line and edit it there. To delete an entry without replacing it, just select the cell (by clicking on the mouse in the selected cell) and press the ***Del*** button on the keyboard.

Another option is to use the ***Erase*** button to delete the entry. Move the cursor to the mistake, then move the mouse to the ***Erase*** button (on the SpeedBar) and click.

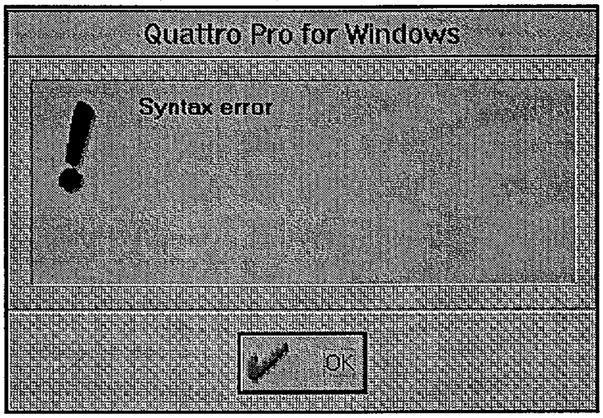


To ***Undo*** any entry or change, move the cursor to the item, then highlight and click on the pencil eraser icon (on the SpeedBar).



Commas, Dollars

QPW won't accept number entries which include a dollar sign ($) or commas (,). Thus, twenty thousand square feet should be entered **20000** and a cost of $10,000 should be entered as **10000**: **$** and **,** are inserted automatically. If you forget and include a "$" or a "," the model will respond with a "Syntax error" message. Click on the **OK**, or press the **Esc** keyboard button, then enter correctly the information requested.



CHAPTER 4: TUTORIAL - WORKED EXAMPLE

The purpose of this chapter is to guide you through a sample data entry exercise. This example is provided for the convenience of the less experienced computer user.

STARTING THE WORKED EXAMPLE

Step One

Start Quattro Pro for Windows (QPW). See instructions in Chapter 3.

Step Two

Open the desired Benefit-cost program file. See instructions in Chapter 3. For the worked example, open the **BC_EXAMP.WB1** file.

Step Three

The **Sign-On** Screen appears after the benefit-cost program is loaded. Adjust the zoom factor if necessary. See instructions in Chapter 3.

Step Four

Proceed through the Data Input process, as outlined below in the tutorial example. This example leads you through a sampling of the data input process.

DATA INPUT

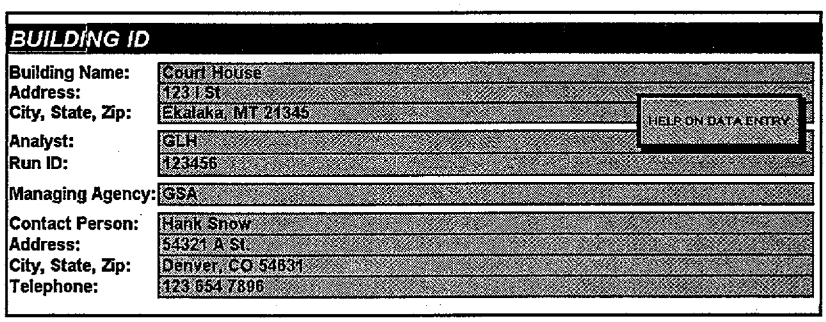
This tutorial will lead you through part of the data entry process for a sample project.

BUILDING ID

Begin Data Entry

Click on **Building** in the menu at the top of the screen. Then click on **Engineering**, and finally, click on **Building Identification**.

The following screen appears:



Building Name

PINK BLOCKS (information only): With your mouse, move the cursor to the first pink-colored block, **Building Name**, and click on the cell. Type the name of the building, e.g., **Federal Building**. Press the **Enter** key.

> **IMPORTANT:** the cursor must be **in the first space on the left inside the pink box**.

Address

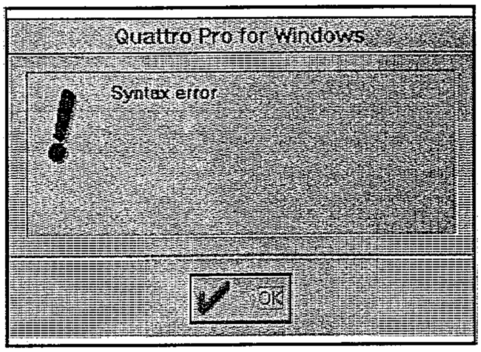
Then, with the mouse or the arrow keys, move the cursor to the street **Address** and enter it in the following way:

'1000 First St

OOPS!

If you forget to start your entry with an apostrophe, ', an error message will be displayed.

Error Message:



Help

The address (and all combinations of numbers and letters **which begin with a number**) **MUST** be entered with a single apostrophe, ', preceding the address, e.g., **'1000 First St**. If not entered this way, a "syntax error" message will appear: click on the **OK** of the error message or press the **Esc** key. Add the apostrophe, then press **Enter.**

City, State, Zip Code

PINK BLOCK (information only): Enter the city, state and zip code for the building: **San Jose, CA 90000**.

Analyst

PINK BLOCK (information only): Enter the name of the person performing this analysis. Enter: **A. Analyst.**

Run ID

PINK BLOCK (information only): Enter a name or number to distinguish this rehabilitation scheme from others which may be analyzed.

Managing Agency

PINK BLOCK (information only): Enter the name of the agency which owns or manages the building.

Contact Person

PINK BLOCK (information only): Enter the name and other information about the building's manager.

BUILDING TYPE

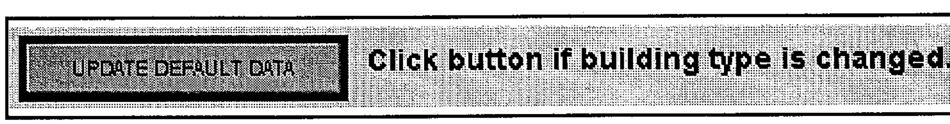
Building Type

GREEN BLOCK (Data input): Enter **P** (as a CAPITAL letter) in the left **GREEN** block. The screen will display the corresponding building description (Unreinforced Masonry Bearing Wall) from the list.

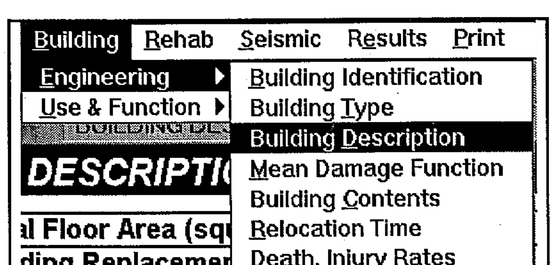
If you make a mistake, use the backspace key to erase, and enter the information correctly. If you have already pressed the **Enter** key, use the mouse to point the cursor at the **GREEN** cell and click. Then enter the correct letter.

Update Default Data

You **MUST** click on the **UPDATE DEFAULT DATA** button to update the default data presented later in the model. **Otherwise, incorrect default data will be presented for your review, and if not overridden (see below), will be used in the benefit-cost calculation.**



Use the mouse to highlight the **Building|Engineering|Building Description** in the menu, or click on the **BuildID** tab at the screen bottom.



BUILDING DESCRIPTION

BUILDING DESCRIPTION		
Total Floor Area (square feet):	20,000	Calculated
Building Replacement Value per square foot	$150	$150
Total Building Replacement Value	$3,000,000	$3,000,000
Number of Stories Above Grade:	3	
Date of Construction	1955	
Historic Building Controls?	NO	

Floor Area

GREEN block (Data entry): Enter **20000** as the total floor area of the building in square feet.

Helpful Hint: The program won't accept numbers which include a dollar sign ($) or commas. Thus, twenty thousand square feet should be entered **20000** and a cost of $10,000 should be entered as **10000**: **$** and **,** appear automatically. If you forget and include a "$" or a "," the model will respond with a "syntax error" message. Click on the **OK**, then enter correctly the information requested.

Building Value (per Sq. Ft.)

GREEN block (Data entry): Enter **150** as the building replacement value per square foot.

Total Building Value

GREEN block (Data entry): Enter **3000000** as the total building replacement value. The model will display **$3,000,000.**

Stories

PINK block (Information): Enter **3** as the number of stories above ground in this building.

Date

PINK block (Information): Enter **1955** as the year the building was constructed.

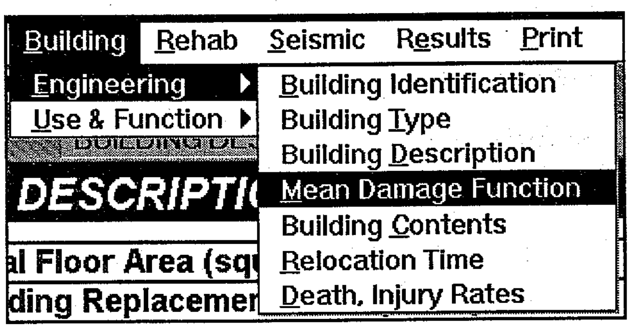
Historic Building

PINK block (Information): Enter **NO**, no historic building controls exist for this structure.

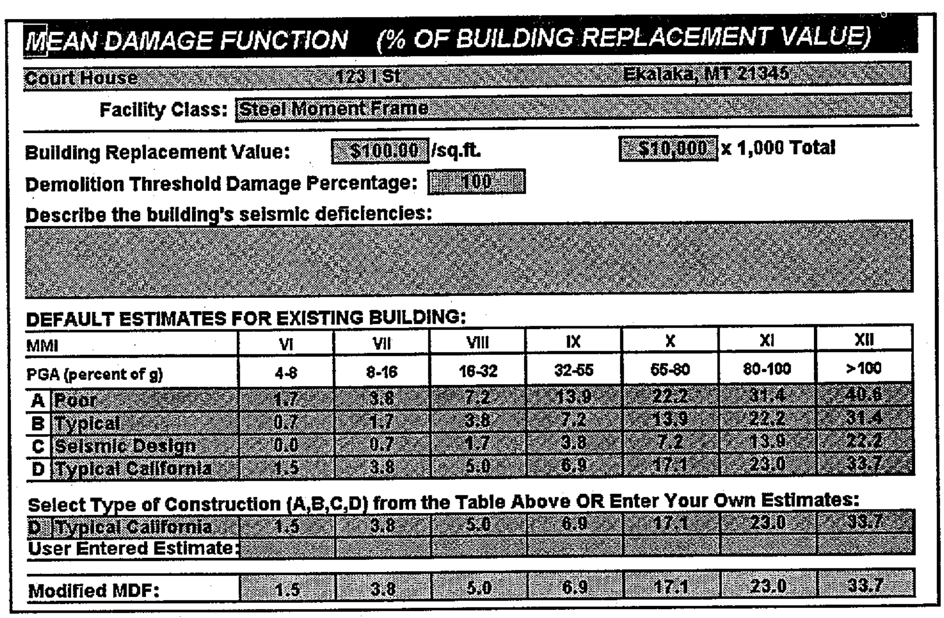
MEAN DAMAGE FUNCTION (% OF BUILDING REPLACEMENT VALUE

Mean Damage Function

Use the mouse to move the cursor to **Building** on the menu at the top of the screen. Click the left mouse button on **Engineering** and again on **Mean Damage Function**, or click on the **MDF** tab at the screen bottom.



The following screen will appear:



MEAN DAMAGE FUNCTION (% OF BUILDING REPLACEMENT VALUE)

Court House 123 I St Ekalaka, MT 21345

Facility Class: Steel Moment Frame

Building Replacement Value: $100.00 /sq.ft. $10,000 x 1,000 Total

Demolition Threshold Damage Percentage: 100

Describe the building's seismic deficiencies:

DEFAULT ESTIMATES FOR EXISTING BUILDING:

MMI	VI	VII	VIII	IX	X	XI	XII
PGA (percent of g)	4-8	8-16	16-32	32-55	55-80	80-100	>100
A Poor	1.7	3.8	7.2	13.9	22.2	31.4	40.8
B Typical	0.7	1.7	3.8	7.2	13.9	22.2	31.4
C Seismic Design	0.0	0.7	1.7	3.8	7.2	13.9	22.2
D Typical California	1.5	3.8	5.0	6.9	17.1	23.0	33.7

Select Type of Construction (A,B,C,D) from the Table Above OR Enter Your Own Estimates:

D Typical California	1.5	3.8	5.0	6.9	17.1	23.0	33.7
User Entered Estimate:							
Modified MDF:	1.5	3.8	5.0	6.9	17.1	23.0	33.7

PURPLE BLOCKS (Carry over): The model displays information entered on the first screen in **PURPLE** blocks. If any of this information is incorrect, return to the data entry screens, **Building ID** and **Building Description** and make necessary changes there.

Demolition Threshold

GREEN block (Data input): Enter **65** as the percentage of damage, relative to the building replacement value, at which the structure would be demolished and replaced rather than repaired.

Building Seismic Deficiencies

PINK block (Information): Enter **See Smith & Brown report for seismic performance engineering evaluation.** This comment box can be used to annotate building deficiencies or to reference information sources about the building.

Default Estimates

ORANGE BLOCKS (Default): The model displays default estimates for the estimated damage, as a percentage of the building replacement value, expected to occur in various MMI bins. For reference, four different mean damage functions are shown.

Construction Type

GREEN BLOCK (Data input): Enter **B**, for typical construction, in the **GREEN** block. This selects "typical" as the default mean damage function most appropriate for the building under consideration.

User Entered Estimate

BLUE BLOCKS (Override default): In this example, leave these blocks empty.

> However, when entering information on actual projects, the model will produce better results with building-specific information.

Modified MDF

YELLOW Blocks (Results): The model displays calculated values for the mean damage function modified for the demolition threshold entered above.

Tutorial Note

To perform a complete benefit-cost analysis of a real project, additional data entries are required. These entries are accessed, like those described above, by clicking on the menu headers and filling in the requested information.

Each data entry is described in detail in Chapter 5. However, this tutorial covers only a sample of the total data entries.

The following section of this tutorial describes the **Results** section, with the remaining data entries already completed.

BENEFIT-COST RESULTS

Click the mouse on **Results**, then click on **Benefit-Cost Results** to view the results calculated by the model.

BENEFIT COST RESULTS

Federal Building	1000 First Street	San Jose, CA 90000
Facility Class:	Unreinforced Masonry Bearing Wall	
Project Description:	0	

A. ECONOMIC PARAMETERS :

Discount Rate:	7	percent
Planning Period:	30	years
Present Value Coefficient:	12.41	

A. ECONOMIC PARAMETERS

Discount Rate

GREEN block (Data input): Enter **7** for the discount rate.

Planning Period

GREEN block (Data input): Enter **30** years for the planning period.

Present Value Coefficient

YELLOW block (Calculated results): The model displays **12.41** as the **Present Value Coefficient**, the present value of $1 per year in benefits received over the project useful lifetime period.

B. SUMMARY OF DAMAGES AND ECONOMIC LOSSES (excluding the value of life)

B. SUMMARY OF DAMAGES AND ECONOMIC LOSSES:

	Annual Expected	Annual Avoided	Annual Residual	Present Value of Damages Avoided
Building Damages	$47,679	$32,504	$15,174	$403,346
Contents Damages	$7,870	$5,392	$2,478	$66,908
Relocation Expenses	$0	$0	$0	$0
Rental Income Losses	$7,549	$3,736	$3,813	$46,360
Value of Lost Services	$10,806	$7,936	$2,870	$98,475
Total Damages and Losses	$73,904	$49,568	$24,336	$615,090

PRESENT VALUE OF TOTAL DAMAGES AND ECONOMIC LOSSES AVOIDED:	$615,090
TOTAL COSTS OF THE SEISMIC REHABILITATION PROJECT:	$560,000
TOTAL BENEFITS MINUS TOTAL COSTS WITHOUT THE VALUE OF AVOIDED INJURIES & DEATHS:	$55,090
BENEFIT COST RATIO WITHOUT THE VALUE OF AVOIDED INJURIES & DEATHS:	1.10

YELLOW blocks (Calculated results): The model displays calculated values for the annual expected, annual avoided, and annual residual damages and losses; and the present value of damages avoided for building and contents damages, relocation expenses, rental income losses and the value of lost services.

Avoided Losses

In the individual **YELLOW** blocks, the model displays the calculated results of the model. The first amount, **$615,090**, is the present value of the damages and economic losses excluding the value of life, which would be avoided if the proposed rehabilitation project is undertaken. **This value is the calculated benefits of the seismic rehabilitation project.**

Project Cost

The second amount, **$560,000**, is the total cost of the proposed rehabilitation project.

Net Benefits

The third amount, **$55,090**, is the value of the net benefits of the proposed project (total benefits minus total costs).

Benefit-Cost Ratio

The last number, **1.10**, is the ratio of net benefits to net costs, excluding the value of life, for the proposed rehabilitation project.

C. VALUE OF INJURIES AND DEATHS

C. VALUE OF INJURIES AND DEATHS:

Value of Avoiding a Minor Injury:	$1,000
Value of Avoiding a Serious Injury:	$10,000
Statistical Value of Life:	$1,700,000

	Annual Expected Number	Annual Avoided Number	Annual Residual Number	Present Value of Damages Avoided
Minor Injuries	5.66E-02	5.09E-02	5.66E-03	$632
Serious Injuries	1.72E-02	1.70E-02	1.72E-04	$2,111
Deaths	7.08E-03	7.07E-03	7.08E-06	$149,136
			Total Value	$151,879

PRESENT VALUE OF TOTAL DAMAGES, ECONOMIC LOSSES, DEATHS AND INJURIES AVOIDED:	$766,969
TOTAL BENEFITS MINUS TOTAL COSTS WITH THE VALUE OF AVOIDED INJURIES & DEATHS:	$206,969
BENEFIT COST RATIO WITH THE VALUE OF AVOIDED INJURIES & DEATHS:	1.37

Minor Injury

GREEN block (Data input): The model displays **$1,000** as the value of a minor injury. In this example, do not change this value.

Major Injury

GREEN block (Data input): The model displays **$10,000** as the value of avoiding a serious injury. Do not change this value.

Statistical Life

GREEN block (Data input): The model displays **$1,700,000** as the value of a statistical life. In this example, do not change this value.

YELLOW blocks (Calculated results): The model displays calculated values for the annual expected, annual avoided, and annual residual costs; and the present value of damages avoided for minor injuries, major injuries, and statistical life.

Avoided Losses

In the individual **YELLOW** blocks, the model displays the calculated results of the model. The first amount, **$766,969**, is the present value of the damages and economic losses including the value of life, which would be avoided if the proposed rehabilitation project is undertaken. **This value is the calculated benefits in the benefit-cost model of the seismic rehabilitation project when the value of casualties avoided is included.**

Project Cost

The second amount, **$206,969**, is the total net benefit of the project (benefits minus costs) including the value of life.

Benefit-Cost Ratio

The third number, **1.37**, is the **benefit-cost ratio** including the value of life.

To Exit From the Tutorial

To exit from the tutorial, click on **File**, then click on **Quit**.

CHAPTER 5: DATA ENTRY

This chapter describes the input data parameters and the data entry process. For guidance on moving around within data entry screens, entering data, erasing mistakes, etc., see the Chapter 3, Program Basics, and Chapter 4, Tutorial - Worked Example, or see the Quattro Pro Manual.

Menu Trees

The benefit-cost model is driven from a customized Quattro Pro menu tree. The main menu headings appear at the left of the menu line at the top of the display screen (after the model is loaded).

The main customized menu tree for the benefit-cost model is integrated with the normal Quattro-Pro screen and appears as follows:

File	Model	Building	Rehab	Seismic	Results	Print

The underscored letter of the menu indicates that, in addition to clicking on the menu word, that this menu can be accessed by an /X keyboard command, where X is the underscored letter in the menu label.

The first seven menu labels above are custom labels for the benefit-cost software. Each menu accesses a range of information about the model:

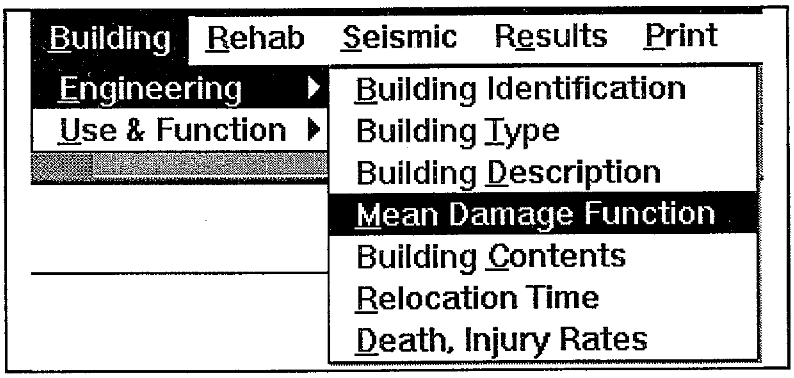
File	controls saving and naming files and closing the current analysis
Model	model version, date and authors
Building	data about the existing building
Rehab	data about a specific rehabilitation project
Seismic	seismic risk data for the site under consideration
Results	summary of damages and losses, casualties, benefit cost results and summary of all data input parameters
Print	controls printing of all data and results pages

Model Menu

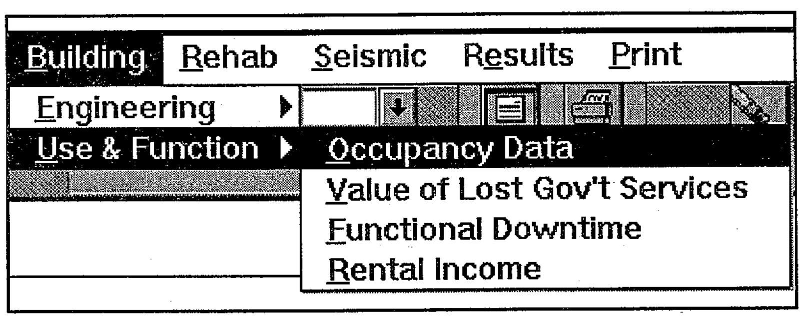
Clicking on **Model** brings up the **Version** submenu header. Clicking on **Version** brings up the title screen of the benefit-cost model. The title screen identifies the version number, date of the version being run, and author identification.

Building Menu

The Building menu label accesses data entry screens for the existing building (before seismic rehabilitation). There are two submenus: Engineering and Use & Function. The Engineering menu has seven submenus: Building Identification, Building Type, Building Description, Mean Damage Function, Building Contents, Relocation Time, and Death, Injury Rates:



The Use & Function menu has four submenus: Occupancy Data, Value of Lost Government Services, Functional Downtime, and Rental Income:



Engineering Menus

BUILDING ID

Building Information	**Building Name** **Address** **City, State, Zip** Enter the basic identifying information about the building under consideration: building name, address, city, state and zip code.
Analyst	**PINK BLOCK** (information only): Enter the name of the analyst(s) conducting the benefit cost analysis.
Run Id	**PINK BLOCK** (information only): Enter a name or number to distinguish this rehabilitation scheme from others which may be analyzed.
Managing Agency	**PINK BLOCK** (information only): Enter the name of the agency which owns or manages the building.
Contact Person	**PINK BLOCK** (information only): Enter the name, address, complete address, and telephone number for the building's manager.

BUILDING TYPE

Building Type
Building type denotes the primary structural systems of buildings. Select the building type most appropriate for the building under consideration from the building type table by entering the appropriate capital letter in the shaded box.

Building type: enter CAPITAL letter code in the green box.

C | Steel Moment Frame

UPDATE DEFAULT DATA | Click button if building type is changed.

FEMA 178	Letter Code	Common Building Types
W1	A	Wood Light Frame
W2	B	Wood (commercial or industrial)
S1	C	Steel Moment Frame
S2	D	Steel Braced Frame
S3	E	Steel Light Frame
S4	F	Steel Frame with Concrete Shear Walls
S5	G	Steel Frame with URM Infill
C1	H	Concrete Moment Frame
C2	I	Concrete Frame with Concrete Shear Wall
C3	J	Concrete Frame with URM Infill
PC1	K	Precast Concrete Tilt-up w/ Flexible Diaphragm
PC2	L	Precast Concrete Frame w/ Concrete Shear Walls
none	M	Precast Frame w/o Shear Walls
RM1	N	Reinforced Masonry w/ Flexible Diaphragm
RM2	O	Reinforced Masonry w/ Precast Concrete Diaphragm
URM	P	Unreinforced Masonry Bearing Wall
none	Q	Mobile Homes
	R	OTHER (Please specify

The designation of building type is a very important data input for the benefit-cost analysis because many of the default parameters in the analysis, including the building's damage function, depend on building type. Therefore, unless building-specific input parameters are entered later in the data entry process, designation of building type will markedly affect the results of the analysis.

If none of the listed building types are appropriate for the building under consideration, enter select the "OTHER" option by entering "R" in the building type selection box. If the "OTHER" option is selected, then default values cannot be provided by the program and all data parameters must be user-entered.

UPDATE DEFAULT DATA | **Click button if building type is changed.**

The model will recalculate after you enter your selection **only if** you either click on the button underneath the Green box where you entered your selection. However, if you have split the screen to display both this and the Results pages, you **must** click on this button to see the recalculated results.

BUILDING DESCRIPTION

This section contains additional descriptive information about the building. Enter the total floor area of the building, the building replacement value per square foot and the total building replacement value. The program calculates the building replacement value and if it is inconsistent with the entered value, displays an error message. Re-enter the correct values so that the calculated values (in the yellow blocks) and the entered values agree. If the total square feet and total building replacement value are entered, the model will calculate and display (in the yellow blocks) the replacement value per square foot.

Total Floor Area (square feet):	520,000		Calculated
Building Replacement Value per square foot	$150		$150
Total Building Replacement Value	$78,000,000		$78,000,000
Number of Stories Above Grade:	10		
Date of Construction	1910		
Historic Building Controls?	Yes		

Replacement building value (per square foot) is the cost of replacing a building with a new building of equivalent function. Seismic damages are estimated as percentages of replacement value. In some cases, a distinction may be made between "reproduction" which is duplication of the previous building, and "replacement" which refers to duplicating a building's function with another (generally more modern) construction type. In most cases, however, the costs to replace a destroyed building with a similar building are readily identifiable. This value is for the building only, excluding contents.

For historic buildings, reproduction value, rather than replacement value, may be a more appropriate measure of building value. If desired, the reproduction value of a historic building can be entered in the "replacement value" data entry box.

The last three data entries under the Building Description section are for informational purposes only (i.e., they are intended to help guide the user in analyzing the building, but entries in these boxes do not affect the benefit-cost results calculated). These entries include: number of stories, date of construction, and historic building controls? (yes or no).

MEAN DAMAGE FUNCTION (% OF BUILDING REPLACEMENT VALUE)

Purple cells contain information carried forward after being entered earlier in the model.

Demolition Threshold Damage Percentage

The demolition threshold damage percentage reflects the fact that many buildings will be demolished rather than repaired when the cost of repairing seismic damage exceeds some percentage of the replacement cost. For older, somewhat substandard buildings, the demolition threshold may be quite low (e.g., 20 or 30%). For typical, relatively modern buildings, the demolition threshold will be higher (e.g., circa 50%). For some particularly important historical buildings, the demolition threshold may approach 100%. The demolition threshold damage percentage may substantially affect the benefit-cost results when the threshold is set lower than the percentage damages expected in earthquakes. For example, if in a given MMI or PGA bin, the MDF is 70% damage and the threshold is 50%, then this MDF bin is adjusted to show 100% damage because the building will be demolished if 70% damage occurs.

The demolition threshold damage percentage, an important policy parameter, may significantly affect the benefit-cost results.

Enter the Demolition Threshold Damage Percentage in the green cell.

Demolition Threshold Damage Percentage: 100

Describe the building's seismic deficiencies:

Comment Box

The pink comment box is intended for a brief synopsis of the seismic evaluation of the building or for any other comments relevant to the building's seismic performance. If a detailed engineering analysis is available for the building, this comment box may also be used to identify reports or other sources of information on the building.

Mean Damage Functions

Building mean damage functions (MDF) indicate a building's seismic vulnerability by showing the expected levels of damage (as a percentage of building replacement value) for each MMI/PGA bin. For reference, up to four typical building mean damage functions are provided for the building type of the building under consideration.

DEFAULT ESTIMATES:

	MMI	VI	VII	VIII	IX	X
	PGA (percent of g)	4-8	8-16	16-32	32-55	55-
A	Poor	5.7	16.1	20.8	44.9	66.
B	Typical	1.5	5.7	16.1	20.8	44.
C	Seismic Design	0.0	1.5	5.7	16.1	30.
D	Typical California	3.0	6.8	15.7	30.2	45.

Select Type of Construction (A,B,C,D) from the Table Above OR Enter Y

D	Typical California	3.0	6.8	15.7	30.2	45.
	User Entered Estimate:					

The user may select one of these "default" mean damage functions by entering the appropriate letter in the green box or may enter a user-determined, building-specific MDF for the building. For some building types, the model will display blanks and inconsistencies in the data because these values are taken directly from the original data sources.

The "poor," "typical," and "seismic design" default estimates are from Earthquake Loss Evaluation Methodologies and Databases for Utah, Technical Report: Task 7, Appendix E and F, dated March 10, 1994, prepared by the Applied Technology Council, Redwood City, California, for the Federal Emergency Management Agency (unpublished). These data have neither been tested nor evaluated. Furthermore, these damage functions are specifically for Utah. These damage functions may approximately represent buildings in other states without a long history of seismic design requirements (i.e., most states other than California).

"Typical" indicates a structure of normal or common construction for the building type. "Poor" indicates a building with substantially worse than normal seismic performance due to poor design and/or poor condition. "Seismic design" indicates a building specifically engineered to resist lateral forces.

The "Typical California" default damage functions are for California buildings and are taken from ATC-13 (Earthquake Damage Evaluation Data for California, Applied Technology Council, 1985).

For the MDF, as for all other data input parameters, better data input means better results and, therefore, users are strongly encouraged to enter building-specific data whenever possible. In entering a building-specific MDF, the user should consider the full range of engineering information about the building, including plan and vertical irregularities and any other seismic deficiencies. The program can handle any type of building accurately, as long as a MDF commensurate with the building is entered.

Individual buildings may have <u>much</u> worse seismic performance than typical buildings (or even poor buildings), depending on the details of the design and construction. Building irregularities, such as soft first stories, may profoundly affect building performance. A truly poor building, in which full or partial collapse is expected in moderate earthquakes would be a prime candidate for seismic rehabilitation. If the benefit-cost results are to reflect accurately the true seismic vulnerability of such a building (and thus to reflect accurately the benefits of rehabilitation) the irregularities and other deficiencies of a building MUST be reflected in the MDF. Thus, engineering judgement and analysis must be used to ensure that the MDF entered for a specific building accurately reflects the expected seismic performance of the building.

> Mean Damage Function (MDF) is one of the **critical** input parameters. The selected MDF **must** be a reasonable representation of the building under evaluation or else the results will be inaccurate. Use **building-specific** values **whenever possible** to produce valid results!

Modified Mean Damage Function

Modified mean damage functions (MMDF) reflect the impact of the demolition threshold as shown below:

Select Type of Construction (A,B,C,D) from the Table Above OR Enter Your Own Estimates:							
D Typical California	1.5	3.8	5.0	8.9	17.1	23.0	33.7
User Entered Estimate:							
Modified MDF:	1.5	3.8	5.0	8.9	17.1	23.0	33.7

In this case, these is no difference between the MDF and the MMDF because the demolition threshold percentage is higher than the highest damage percentage in the MDF. If, for example, the demolition threshold were 20%, then damage percentages in the MMI XI and XII bins in the MMDF would both become 100%, because the damage percentage in the MDF for these bins exceeds the demolition threshold percentage.

BUILDING CONTENTS (Damage as a % of replacement value)

In the pink box enter a brief description of the building's contents.

First, enter the estimated value of total building contents (per square foot) in the $/sf box. The total building contents value is calculated automatically.

Second, an estimate for the contents mean damage function must be made. The default assumption is that the contents MDF is the same as the building MDF. The building MDF (entered previously) is shown for reference.

Users may either accept the default contents MDF estimate, or enter a building-specific estimate. Because the seismic fragility of contents may differ significantly (either higher or lower) than the building fragility, users are strongly encouraged to enter building-specific contents MDF estimates.

RELOCATION TIME (due to seismic damage)

Seismic damage to a building may necessitate relocation while the building is repaired. Default estimates of the number of days of relocation necessary, based on the building MMDF, are provided for reference.

Users may accept the default relocation estimates or enter a building-specific estimate. As always, users are strongly encouraged to enter building-specific estimates whenever possible.

Total relocation costs (dollars per square foot per month) are calculated as the sum of the added costs of relocation per day plus the costs of renting alternative space. The costs of relocation per day include extra operating costs (transportation, communications, etc.) incurred as a result of a forced relocation due to seismic damage. Such costs are highly locality-specific and agency-specific and thus no default values are provided.

DEATH & INJURY RATES (Per 1,000 Occupants) EXISTING BUILDING

Life safety concerns are often one of the prime drivers of seismic rehabilitation projects. Therefore, estimating the life safety threat in the existing building and the efficacy of the rehabilitation in reducing expected future casualties are particularly important data input decisions. For reference, default death and injury (minor and major) rates per 1,000 occupants are shown in this section. These values are from ATC-13 (interpolated) for the building mean damage function selected or entered.

Default Minor Injury Rate	1.65E-01	6.60E-01	2.28E+00	1.38E+01
User Entered Estimate:				
Default Major Injury Rate	2.20E-02	8.80E-02	3.04E-01	1.84E+00
User Entered Estimate:				
Default Death Rate	5.50E-03	2.20E-02	7.60E-02	4.60E-01
User Entered Estimate:				

Users may accept the default values or enter user-specified estimates in the appropriate green boxes. Users are strongly encouraged to enter building-specific estimates.

The importance of entering building-specific estimates for death and injury rates when possible cannot be overestimated. User-entered casualty rates must be consistent with the mean damage function estimates entered previously. The life safety threat posed by specific buildings may vary drastically from "typical" values, depending on the seismic damage pattern, the prevalence of falling object hazards and the age and health of building occupants.

User-entered casualty rates should be consistent with the mean damage function estimates entered previously.

A comment box is provided at the end of the Death and Injury section for user comments and/or references to supporting documentation for casualty estimates.

USE & FUNCTION MENUS

The Use and Function submenu of the Building menu contains information on occupancy, value of government services, functional downtime, and building rental income.

OCCUPANCY DATA

Occupancy

Enter the average number of persons (employees and visitors) for both daytime and nighttime, along with the days per week and hours per day for which these day and night occupancy averages apply. The program calculates the average building occupancy over a 24-hour, 7-days per week period.

OCCUPANCY:	Day	Night	
Average Number of Occupants:	25	1	
Days per Week:	5	5	
Hours per Day	9	9	
Average Occupancy (24 hours, 7 days per week):			6.96

VALUE OF GOVERNMENT SERVICES LOST

The value of government services, which may be lost due to seismic damage, is determined using the Quasi-Willingness To Pay (QWTP) model, which is described more fully in Chapter 1 of Volume 2. Briefly, QWTP assumes that government services are worth what it costs to provide them. For example, if an agency spends $1,000,000 per month to provide services from a given building, then the loss of these services for one month is valued at $1,000,000. For QWTP evaluation, the full costs of providing government services must be counted, including salaries and benefits, utilities and other non-wage operating costs, and either rent or a rent-proxy (if the building is agency owned). Rent proxy is an approximate equivalent to rent for owner-occupied buildings (described below).

QWTP assumes that government services are worth what it costs to provide them.

HELP

Complete EITHER Section 1 or 2 (they are equivalent):

1a. Total annual operating budget of government functions in this building. (DO NOT count pass through funds such as social security payments.)	
1b. Does this include rent? (1=yes, 2=no)	2
2a. Number of full-time-equivalent persons working in the building:	25
2b. Average annual salary-plus-benefits paid to the above:	$50,000
2c. Average annual utilities, and other non-wage operating expenses :	$100,000
Rental Values For Support of Agency Functions	
3a. Amount of floor space occupied by government tenants (sq. ft.):	50,000
3b. Proxy annual rent estimate (if 1a. does not include rent):	$350,000
Daily cost of providing services from this building:	$4,658
Post-Earthquake Continuity Premium	
Based on the nature of the services in this building, how much extra cost per day would the tenant agencies be willing to spend to maintain agency functions after an earthquake:	$2,000
TOTAL VALUE OF LOST SERVICES PER DAY:	$6,658

In compiling costs for the QWTP evaluation, pass through costs such as Social Security payments or other transfers should **not** be counted. Only the direct costs of providing the government services should be counted.

Enter **either** the total annual operating budget for the building (in box 1a) **or** the more detailed breakdown in boxes 2a, 2b, and 2c (number of fulltime equivalent employees, average wages and benefits, average annual utilities and other non-wage operating costs). If total annual operating costs are entered in Box 1a, it is not necessary to fill in Boxes 2a, 2b, and 2c. If all boxes are filled in, the program uses the more detailed values from Boxes 2a, 2b, and 2c.

Rental Values for Support of Agency Function

The proxy annual rent is calculated from the building's replacement value and the discount rate; this value (shown in Box 3a) is used unless the annual operating costs in Box 1a includes rent. If a value for total operating costs is entered in Box 1a, and a "1" is included in Box 1b (total operating costs includes rent), and Boxes 2a, 2b, and 2c are not filled in then the proxy rent value in Box 3b is not used to calculate the daily cost of providing government services from the building.

Post-Earthquake Continuity Premium

The above QWTP calculation is for "normal" government services (i.e., not in the post-earthquake environment). Some government services, such as emergency response or emergency medical care, may be more valuable than normal in the post-earthquake time period. If desired, a post-earthquake continuity premium, the dollar amount agencies would be willing to pay to maintain agency functions after the earthquake, can be included. The QWTP value of government services is the sum of the normal cost to provide government services plus the continuity premium.

FUNCTIONAL DOWNTIME

Functional Downtime

For the QWTP evaluation of the value of lost government services, it is necessary to estimate how long government services will not be provided as a result of seismic damage. Default estimates are provided, based on the building's Mean Damage Function. The default functional downtime estimates are capped at 30 days, because it is assumed that government services will be reestablished within 30 days, in temporary quarters if necessary.

MMI	VI	VII	VIII	IX	X	XI
PGA (percent of g)	4-8	8-16	16-32	32-55	55-80	80-1
Building Damage (%)	3	7	16	30	46	62
Default Downtime (Days)	3	7	16	30	30	30
User Entered (days)						

Analyst: Joe Blow

Users may accept the default estimates of functional downtime, or enter user-specified estimates in the blue boxes provided.

Functional downtime is distinct from relocation time (see Relocation Information section). Estimates for each time will generally be quite different. Relocation time refers to the amount of time that agencies will be relocated out of a damaged building, and, thus, relocation time may be significantly longer than functional downtime.

Functional downtime is distinct from relocation time.

BUILDING RENTAL INCOME

This data entry screen enables the user to enter building-specific rental income information for non-Government tenants. Rental income from Government tenants is considered a transfer payment and not included as a loss in true income.

On this data entry screen, enter the amount of rental space and the rental rate.

Rehabilitation Menus

REHABILITATION PROJECT DESCRIPTION

All of the previously discussed input data are applicable to the **existing building**, and thus are applicable to any rehabilitation project(s) under consideration. The following rehabilitation project data, however, are project-specific (i.e., they apply to a specific project with defined objectives, engineering design and construction, and costs). A range of alternative rehabilitation schemes can be analyzed sequentially by entering appropriate data and obtaining benefit-cost results for each in turn.

This section provides spaces for a brief description of the rehabilitation project under evaluation and a statement of the objective of the rehabilitation.

risk reduction:	any measure to lower seismic risk;
collapse prevention:	the minimum structural strengthening to avoid collapse;
substantial life safety:	collapse prevention and ensuring post-earthquake access and egress;
damage control:	limiting the extent of seismic damage; and
immediate occupancy:	denotes virtually no disruption of function.

If more than one rehabilitation project is being considered, user must be careful to ensure that all of the inputs which apply to the rehabilitation project are commensurate with the specific rehabilitation under evaluation (i.e., costs and effectiveness in avoiding building damages, contents damage, and casualties).

REHABILITATION PROJECT COSTS

This section allows input of the full range of rehabilitation project costs. Data entry boxes are provided for: direct construction costs, indirect costs such as architectural and engineering fees, testing, permits, etc. and for project management. For reference, a data entry box is provided for the base year of costs.

To estimate relocation costs associated with the rehabilitation project (which are included in the total costs of the project), the user must enter the estimated number of months of relocation necessary. Relocation costs are then calculated automatically from relocation cost information entered previously.

Total project costs are calculated from a summation of the above costs.

Default values are not provided for costs because costs are project- and locality-specific. Rehabilitation project cost estimates are readily obtainable using standard construction cost estimating methods.

EFFECTIVENESS OF THE REHABILITATION

The effectiveness of a seismic rehabilitation project is the extent to which the project reduces expected future damages and losses. Effectiveness is characterized by the percentage reduction in expected damages. Five effectiveness estimates must be entered, for: building damages, contents damages, and casualties (minor injury rate, major injury rate and death rate).

Effectiveness in Avoiding Building Damage

The effectiveness of a specific rehabilitation project in avoided future building damages may be viewed from two perspectives. One perspective is to consider the mean damage function (MDF) of the rehabilitated building compared to the MDF of the existing building. Several MDFs for the building type under consideration are shown for reference. The user may select one of these or enter a user-specified, building-specific estimate of the MDF for the rehabilitated building. Percentage effectiveness of the prospective seismic rehabilitation project are calculated from the MDFs for the existing and rehabilitated building.

The effectiveness of seismic rehabilitation projects in avoided future damages may vary markedly from very small percentages for minor risk reduction projects to nearly 100% for projects designed to ensure continued functionality and immediate occupancy in the largest earthquake considered. In general, the effectiveness of many types of rehabilitation projects declines as the intensity of ground shaking increases.

All benefits depend on the estimated effectiveness of the rehabilitation.

The estimated effectiveness in reducing building damages is an extremely important input parameter because avoided building damages typically constitute the largest component of benefits (without the value of life). Furthermore, all of the other benefits (avoided contents damages, avoided rental income losses, avoided relocation costs, avoided loss of government services, and avoided deaths and injuries) depend on the expected building mean damage function after rehabilitation. Therefore, all of the estimated benefits of the rehabilitation project depend on the estimated effectiveness of the rehabilitation in avoiding building damages.

Effectiveness in Avoiding Contents Damage

The effectiveness of the proposed rehabilitation project in avoiding contents damage must also be estimated. The default assumption is that the effectiveness for contents is the same as the effectiveness for the building.

Users may accept this default assumption (which may not always be a good assumption) or enter building- and contents-specific estimates in the appropriate data entry boxes. As always, users are strongly encouraged to enter building-specific estimates whenever possible.

DEATH AND INJURY RATES (per 1,000 occupants): REHABILITATED

Effectiveness in Avoiding Casualties

The effectiveness of the proposed rehabilitation project in avoiding casualties (deaths, major injuries and minor injuries) must also be estimated. For reference, the casualty rates for the existing building (entered previously) are shown. Default estimates are provided based on the assumption that the rehabilitation project reduces minor injuries by a factor of 10, major injuries by a factor of 100, and deaths by a factor of 1,000. These default casualty reduction factors are based on the premise that life safety is the driving force for most seismic rehabilitations.

The effectiveness of rehabilitation projects in avoided casualties may vary markedly depending on the type of building and on the objective and implementation of the rehabilitation. Therefore, it is very important to enter building-specific, project-specific estimates whenever possible.

In some cases, where occupancy is high and a building is expected to undergo partial or full collapse at moderate levels of ground shaking, benefit-cost results may be predominantly determined by the casualties avoided by the rehabilitation. Therefore, estimation of expected casualty rates for the existing building and the reduction in expected casualty rates for the rehabilitated building are among the most important data input decisions.

Seismic Menus

SEISMIC RISK

Seismic risk, the expected annual number (or probability) of earthquakes for the range of MMI/PGA bins, is the single most important determinant of benefit-cost results. Seismic risk may vary by several orders of magnitude from one location in the United States to another. All other factors being equal, benefit-cost results are directly proportional to seismic risk. A more technical review of seismic risk is given in Technical Issues chapter of Volume 2.

Soil Type

Specify the soil type in the green box provided.

The expected level of ground shaking in any given earthquake event depends on the soil type at the site. Site-specific soil conditions may markedly impact the actual ground shaking experienced during earthquakes. Therefore, to model seismic risk it is essential to consider the effects of soils at each site. Soil effects are modeled using a five step soil classification from NEHRP.

For the Default Method (seismic risk based on two pairs of input data) the user must classify the site on a simple five point scale (S0, S1, S2, S3, and S4). Seismic risk estimates at a site are adjusted according to the consensus soils multipliers compiled by the Design Values Panel (1993) which is currently reviewing proposed NEHRP 1993 standards. Because of soil amplification effects, the expected annual number of earthquakes in a given MMI/PGA bin depends on the soil type. The soil multipliers used are shown below:

		% of g			
Soil Description	Class	25	50	75	100
Hard rock	S0	0.6	0.6	0.7	0.8
Rock	S1	0.7	0.8	0.9	1.0
Very dense soil	S2	1.0	1.0	1.0	1.0
Stiff Soil	S3	1.2	1.1	1.0	1.0
Soft soil	S4	1.5	1.3	1.1	0.9

If Option 2 (the Site-Specific Geotechnical Estimate, below) is chosen, then soil effects are assumed to be incorporated into the geotechnical estimate and the soil multipliers shown above are not used.

Seismic Risk Assessment

Seismic risk, the expected annual number of earthquakes as a function of the MMI/PGA bins, for a specific site may be estimated in two ways in the model:

1) DEFAULT METHOD: from tabulated values for about 300 cities in the Seismic Risk Table (below), or by entering values of acceleration and exceedance probability from the 1991 NEHRP appendix maps; or

2) SITE-SPECIFIC GEOTECHNICAL METHOD: enter data from a site-specific geotechnical study.

The user must estimate seismic risk in only one of the above ways.

1) Default Method

The first method provides approximate estimates of seismic risk, based on regional seismicity contours. This method requires entering two pairs of data for spectral acceleration (as a percentage of g, the acceleration of gravity) with a 10 percent chance of exceedance in two time intervals (e.g., 50 years and 250 years). More accurate estimates can be obtained from a site-specific geotechnical study. Therefore, users are strongly encouraged to use site-specific geotechnical data whenever possible.

a) Tabulated Values

The Seismicity Estimates for Major Cities Table (Table 3.1) contains seismic risk data for approximately 260 cities in the United States. These cities include the 200 largest cities, plus an additional smaller cities in higher seismicity areas. For cities in this table, the user can copy the two tabulated spectral acceleration data points into the appropriate boxes on the Seismic Risk data entry screen. These data points were obtained from the spectral acceleration contours on the 1991 NEHRP maps (as described below). From these data points, the program automatically calculates the expected annual number of earthquakes shown in the "default estimate" line of the Seismic Risk Table.

Using the tabulated values in the Cities Tables is convenient; however, seismic risk estimates derived from these tables are subject to two significant uncertainties. First, the spectral acceleration contours on which the tabulated values may not fully reflect all local faults. Second, particularly for cities of large geographic extent, the average values for a city may not reflect important local differences, depending on the location of the major fault(s).

b) NEHRP Maps

Another option is to enter spectral acceleration contour data (i.e., as shown in Table 3.1) for the city of interest. This option may be useful for cities not shown in Table 3.1 or cities of large geographic extent where it may be possible to read the contours to a higher precision than the average city values shown in Table 3.1. This option is still, of course, subject to uncertainties in the contours, which may not accurately reflect all local faults.

The 1991 NEHRP Appendix maps showing contours of spectral acceleration for a period of 0.3 seconds are used to estimate the expected annual numbers of earthquakes for each bin of effective peak acceleration. For cities outside California, Maps 5 and 9, 10% exceedance probabilities in 50 and 250 years are used. For cities within California, Maps 6 and 10 are used.

When using the default seismic risk method, you must click on the Update Seismic Button if any of the seismic values are changed.

2) Site-Specific Geotechnical Method

The second option is to enter site-specific data in the blue blocks. If available, this is by far the preferred option, because it incorporates detailed site-specific information and analysis of local faults and is thus likely to produce more accurate results than the default method.

The preferred option is to have the expected annual numbers of earthquakes in each MMI/PGA bin calculated directly as part of the detailed site-specific geotechnical seismic evaluation.

Table 5.1
Seismicity Estimates for Major U.S. Cities

State	City	50 yr	250 yr
AK	Anchorage		
AK	Juneau		
AL	Birmingham	20	45
AL	Huntsville	15	30
AL	Mobile	1	6.5
AL	Montgomery	11	28
AR	Fayetteville	4	11
AR	Fort Smith	5	14
AR	Little Rock	13.5	29
AR	Pine Bluff	15	35
AZ	Flagstaff	15	40
AZ	Glendale	8	22
AZ	Mesa	7	19
AZ	Phoenix	8	21
AZ	Scottsdale	7.5	19
AZ	Sierra Vista	15	35
AZ	Sun City	8.1	22
AZ	Tempe	7.5	21
AZ	Tucson	8.5	28
AZ	Yuma	25	50
CA	Anaheim	95	200
CA	Bakersfield	50	110
CA	Berkeley	150	250
CA	Chula Vista	110	300
CA	Citrus Heights	18	40
CA	Concord	100	200
CA	East Los Angeles	110	250
CA	El Monte	110	290
CA	Escondido	75	150
CA	Fremont	130	300
CA	Fresno	18	38
CA	Fullerton	90	175
CA	Garden Grove	110	275
CA	Glendale	105	250
CA	Hayward	130	275
CA	Huntington Beach	110	300
CA	Inglewood	110	300
CA	Irvine	105	240
CA	Long Beach	120	300
CA	Los Angeles	110	250
CA	Modesto	20	38
CA	Moreno Valley	100	175
CA	Oakland	130	275
CA	Oceanside	105	275
CA	Ontario	90	180
CA	Orange	90	190
CA	Oxnard	120	180
CA	Pasadena	110	250
CA	Pomona	90	190

State	City	50 yr	250 yr
CA	Rancho Cucamonga	100	200
CA	Riverside	90	175
CA	Sacramento	19	37
CA	Salinas	150	220
CA	San Bernardino	200	300
CA	San Diego	110	300
CA	San Francisco	200	300
CA	San Jose	185	250
CA	Santa Ana	95	225
CA	Santa Clarita	90	200
CA	Santa Rosa	78	175
CA	Simi Valley	80	165
CA	Stockton	25	40
CA	Sunnyvale	190	300
CA	Thousand Oaks	95	200
CA	Torrance	120	300
CA	Vallejo	85	190
CO	Aurora	2.5	10.5
CO	Colorado Springs	3	12.5
CO	Denver	3	11
CO	Lakewood	3	11
CO	Pueblo	4	12.5
CT	Bridgeport	38.5	85
CT	Hartford	36	82
CT	New Haven	40	86
CT	Stamford	38	85
CT	Waterbury	38.5	83
DC	Washington	14	28
DE	Dover	15	34
FL	Fort Lauderdale	1	2
FL	Hialeah	1	2
FL	Hollywood	1	2
FL	Jacksonville	8	22
FL	Miami	1	2
FL	Orlando	6	20
FL	St. Petersburg	1	4
FL	Tallahassee	5	17.5
FL	Tampa	1	6.5
GA	Atlanta	19	44
GA	Columbus	11	28
GA	Macon	10	27
GA	Savannah	14	30
HI	Honolulu		
IA	Cedar Rapids	2	7
IA	Des Moines	2	2
ID	Boise City	9	22
ID	Coeur d'Alene	8	19
ID	Idaho Falls	10	25
ID	Lewiston	7.5	15

State	City	50 yr	250 yr
ID	Pocatello	22	50
ID	Twin Falls	8.6	25
IL	Chicago	5.5	18.5
IL	Peoria	7	16
IL	Rockford	6	19
IL	Springfield	7	17.5
IN	Evansville	21	50
IN	Fort Wayne	7.5	17.5
IN	Gary	5	15
IN	Indianapolis	15	40
IN	South Bend	5	15.5
KS	Kansas City	7	18
KS	Overland Park	7	18
KS	Topeka	10	23
KS	Wichita	10	25
KY	Lexington-Fayette	16	34
KY	Louisville	15	30
LA	Baton Rouge	1	8.5
LA	Metairie	1	8
LA	New Orleans	1	8
LA	Shreveport	2	10
MA	Boston	36	89
MA	Lowell	37.5	70
MA	Springfield	35	88
MA	Worcester	40	82
MD	Baltimore	15	30
ME	Augusta	20	50
ME	Portland	30	58
MI	Ann Arbor	8	22
MI	Detroit	8.5	23
MI	Flint	6	17
MI	Grand Rapids	5	16
MI	Lansing	6.5	16.5
MI	Livonia	8.5	22
MI	Sterling Heights	8.5	20
MI	Warren	9	21
MN	Minneapolis	2.5	11
MN	St. Paul	2	10
MO	Independence	6	18
MO	Jefferson City	7.5	17.5
MO	Kansas City	7	18
MO	Springfield	6	17
MO	St. Louis	27	61
MS	Jackson	3.5	10
MT	Billings	2	5.5
MT	Bozeman	37	93
MT	Butte	20	65
MT	Great Falls	6	13
MT	Helena	32	83
MT	Kalispell	45	125

State	City	50 yr	250 yr
MT	Missoula	12	27
NC	Charlotte	14	29
NC	Durham	10	24
NC	Greensboro	12	28
NC	Raleigh	9.5	22
NC	Winston-Salem	13	29
ND	Bismarck	1	2
NE	Lincoln	15.5	33
NE	Omaha	14	25
NH	Concord	30	50
NH	Manchester	32	53
NJ	Elizabeth	38	85
NJ	Jersey City	38	85
NJ	Newark	38	85
NJ	Paterson	38	85
NJ	Trenton	37.5	83
NM	Albuquerque	28	55
NM	Santa Fe	7.5	20
NV	Carson City	65	155
NV	Las Vegas	13	32
NV	Paradise	13	35
NV	Reno	62	155
NY	Albany	25	50
NY	Buffalo	23	58
NY	New York	38	84
NY	Rochester	23	83
NY	Syracuse	9	20
NY	Yonkers	38	85
OH	Akron	15	40
OH	Cincinnati	15.5	33
OH	Cleveland	15	40
OH	Columbus	13	30
OH	Dayton	15.5	30
OH	Toledo	13	30
OK	Oklahoma City	10.5	22
OK	Tulsa	8.5	20
OR	Albany	33	80
OR	Corvalis	37	87
OR	Eugene	31	82
OR	Grants Pass	24	80
OR	Klamath Falls	15	40
OR	Medford	19	60
OR	Portland	42	82
OR	Salem	39	80
OR	The Dalles	25	50
PA	Allentown	32	80
PA	Erie	15	30
PA	Harrisburg	27	60
PA	Philadelphia	37	84
PA	Pittsburgh	6	14

State	City	50 yr	250 yr
RI	Providence	40	83
SC	Columbia	30	65
SD	Pierre	7.5	21
SD	Sioux Falls	4	14
TN	Chattanooga	21.5	48
TN	Knoxville	23	53
TN	Memphis	60	150
TN	Nashville-Davidson	14	30
TX	Abilene	1	6.6
TX	Amarillo	7.5	20
TX	Arlington	4	12.5
TX	Austin	1	7.2
TX	Beaumont	1	7.8
TX	Corpus Christi	1	7.5
TX	Dallas	5	14
TX	El Paso	2.5	15
TX	Fort Worth	3.5	12.5
TX	Garland	5	14
TX	Houston	1	8
TX	Irving	5	13
TX	Laredo	1	5
TX	Lubbock	2	7
TX	Mesquite	5	12.5
TX	Pasadena	1	8.5
TX	Plano	6	18
TX	San Antonio	1	7.2
TX	Waco	1	7
UT	Logan	48	100
UT	Ogden	37	85
UT	Provo	37	90
UT	Salt Lake City	35	75
UT	Tooele	25	64
VA	Alexandria	13.8	29
VA	Arlington	14	29
VA	Chesapeake	12.5	27
VA	Hampton	15	35
VA	Newport News	14	34
VA	Norfolk	13	28
VA	Portsmouth	12.5	25
VA	Richmond	20	74
VA	Virginia Beach	10	20
VT	Montpelier	14.5	28
WA	Bellevue	83	141
WA	Bellingham	64	110
WA	Bremerton	83	150
WA	Everett	74	140
WA	Longview	50	85
WA	Olympia	75	136
WA	Richland	18	32

State	City	50 yr	250 yr
WA	Seattle	84	150
WA	Spokane	11	21
WA	Tacoma	85	147
WA	Vancouver	45	82
WA	Yakima	28	58
WI	Madison	5	16
WI	Milwaukee	5.5	17
WV	Charleston	8	18
WY	Casper	3	12
WY	Cheyenne	2	11
WY	Laramie	2	12
WY	Sheridan	2.5	10

Other Data Inputs

There are five additional data inputs required: discount rate, planning horizon, and three value of life amounts for deaths, minor injuries, and major injuries. These data inputs are discussed in Chapter 6 (Results) in the Benefit-Cost Results section because they are independent of either the existing building or the rehabilitated building.

These economic inputs strongly affect any benefit-cost calculation. For consistency, we suggest that decisions about these economic inputs should probably be made at the agency level, rather than on a building-by-building basis. Agency-wide consistency is essential if benefit-cost results are to be used as part of the decision-making process of prioritization of seismic rehabilitation projects.